COPPER
IN CANADA

Canada is among the world's leading producers of copper, one of the most useful and important metals known. In recent years, annual production of newly mined copper in this country has averaged well over 700 000 tonnes.

Copper was the first metal used on earth. It was found on the surface in the form known as native copper, probably as early as 13 000 B.C.

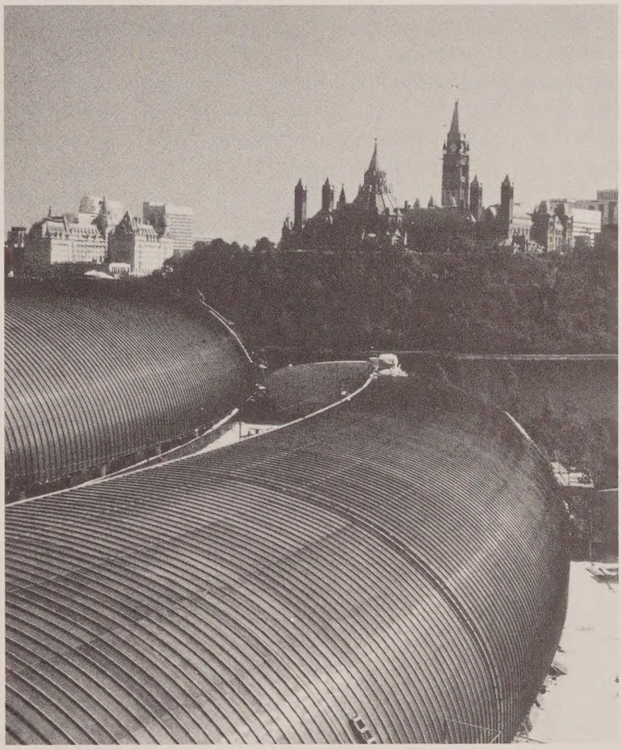
The first major developments in the use of copper occurred in the area encompassing the valleys of the Tigris and Euphrates to the northwest of the Persian Gulf. Copper objects have been found there that date back to 4500 B.C. or earlier.

Implements from China, Egyptian obelisks, Grecian urns and Roman mirrors, all fashioned from copper, provide some of the best indications and records of the ancient civilizations. Copper has been used for coinage since ancient times. The fact that these age-old copper objects have been discovered in many areas of the world is proof of the metal's unique properties of durability, resistance to corrosion, permanence and ease of fabrication.

The Romans designated copper as *aes cyprium* or 'metal of Cyprus', the island of Cyprus being one of the earliest sources of the metal. The name became *cyprium*, then *cuprum*, from which the chemical symbol Cu is derived, and finally copper.

The Inuit and Indians of North America used and traded copper implements long before the first recorded discovery of copper by explorers in Canada. In 1604, an exploration party under Champlain found native copper at Cap d'Or, Nova Scotia. One year earlier, a French explorer, Prévert, had visited the Gaspé interior and he reported to Champlain that he had seen a glistening mountain. This description fits the now-famous Copper Mountain and probably was the first copper showing in Canada known to Europeans.

The first indication of the rich copper deposits in the Lake Superior area came in 1770, when the Jesuit Fathers experimented with native copper found at Point Mamainse, on the north shore. In 1771, Samuel Hearne, a Hudson's Bay clerk, prospected the Coppermine River area of the Northwest Territories.



CANADIAN COPPER & BRASS DEVELOPMENT ASSOCIATION

Sheet copper for roofing. The old (Parliament Buildings) and the new (Museum of Civilization).

DEVELOPMENT OF THE INDUSTRY

Copper mining in Canada commenced with the discovery that led to the estab-

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Canada

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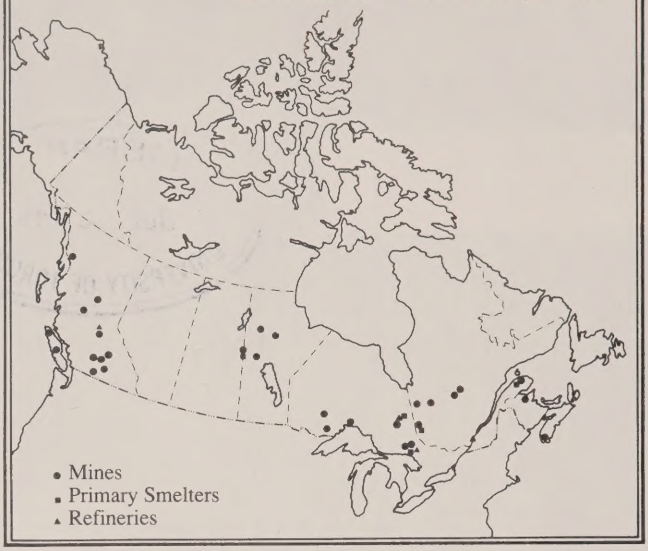
Copper in Canada, 1989



lishment, in 1847, of the Bruce Mine in the Algoma district of Ontario. Development continued on a small scale and, in 1886, the first year in which statistics on Canadian copper output were kept, the total recorded production was only 1590 tonnes. By 1940, mine production had increased to 298 000 tonnes per year, and over 700 000 tonnes per year by the early 1970s.

Occurrences of copper minerals in Canada are very widespread. However, concentrations of copper-bearing ore that permit profitable exploitation are confined to relatively few locations. In 1989, there were about 50 mines in Canada that produced copper. Within Canada, four provinces, British Columbia, Ontario, Quebec and Manitoba, account for the bulk of copper production.

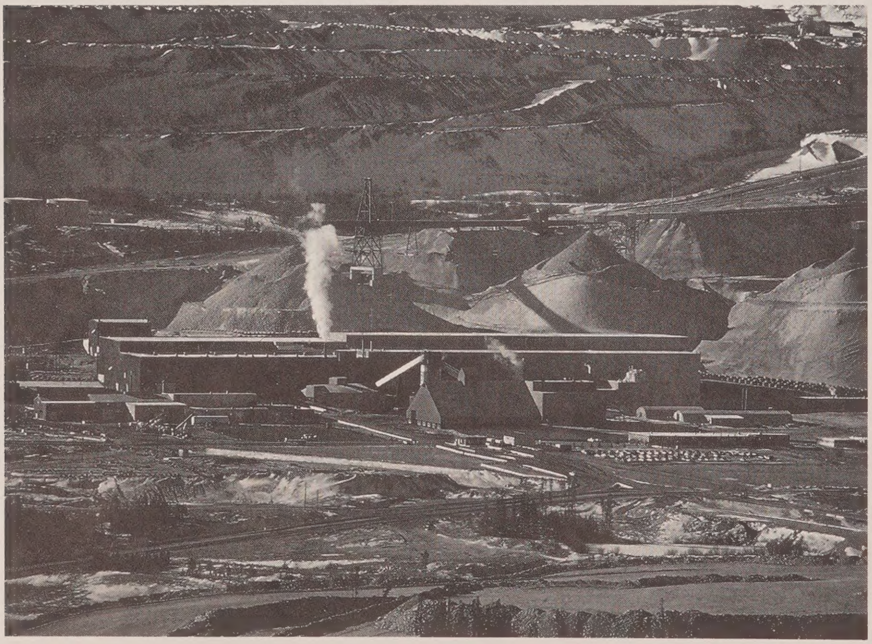
British Columbia is the largest copper-producing province. The first recorded copper production in that province was in 1890. In that year an ore shipment was made from the Silver King and Skyline mines in the Nelson Mining Division to the Anaconda smelter at Helena, Montana. Rapid expansion of the industry in British Columbia did not occur, however, until the period 1960-73, with the development of a number of large phorphyry copper deposits including Bethlehem, Similkameen, Lornex, Brenda, Gibraltar, Bell and Granisle.

Ontario, the second largest copper-producing province, owes much of its importance to the Sudbury region where the metal is recovered in conjunction with nickel mining operations. In the 1970s, the rich Kidd Creek orebody near Timmins was developed, providing the province with a second major copper-producing region.

Large-scale copper mining began in Quebec with the opening of the Horne mine at Noranda late in 1927. The industry also developed in western Quebec in the Matagami, Joutel and Louvicourt districts, in central Quebec in the Chibougamau area, in the south in the Stratford region, and in the east in the Gaspé region.

Manitoba, Canada's fourth largest copper-producing province, has three major producing areas, Flin Flon, Ruttan Lake and Snow Lake. The Flin Flon ore deposits on the Manitoba-Saskatchewan boundary were discovered in 1915.

Elsewhere in Canada, copper is recovered in minor amounts in the Atlantic provinces, the Yukon and the Northwest Territories.



Highland Valley Copper

View of coarse ore piles and concentrator at the Highland Valley Copper mine in British Columbia.

From Mine to Manufacturer

In nature, copper is usually associated with other metals such as zinc, nickel, molybdenum and gold. Copper combines with sulphur and iron to form sulphide minerals which may occur with these metals in either massive sulphide deposits or as

disseminated deposits known as porphyries.

The most common copper deposits in Canada are accumulations of massive sulphides from volcanic or magmatic activity, and porphyries which have a magmatic origin. Economic massive sulphide deposits normally contain concentrations of about 2 per cent copper. Porphyry deposits, although containing lower concentrations of copper, are usually much larger in volume.

Orebodies at or near the surface are usually mined by open-pit methods. Blasting breaks the ore into pieces small enough to be loaded into trucks or railway cars and dumped into a crusher. Open-pit mining methods are generally less costly than underground methods, and in Canada some orebodies containing as little as 5 kg of copper per tonne are being mined by this method.

When an orebody occurs at depth it must be mined by underground methods. A shaft, usually a vertical opening, is sunk and horizontal tunnels are driven from the shaft at intervals. Again, the ore is broken by blasting to a size that can be handled conveniently and then transported to an underground crusher. After crushing, the ore is hoisted to the surface.

The ore is further crushed, ground and mixed with water to form a pulp. In a process called flotation, small controlled amounts of chemical compounds are added to the pulp to create a froth. Valuable minerals are carried in this froth, which floats to the surface while the unwanted mineral particles sink. The retained minerals are removed as a copper concentrate.

While there are a number of different technologies that are used to process the concentrate and ultimately yield copper metal, all utilize smelting and conversion phases to remove iron and sulphur. During these stages, oxidized iron combines with silica to produce an iron silicate slag while sulphur is oxidized to produce sulphur dioxide gas. The resultant metal, known as blister, contains about 99 per cent copper.

The blister is cast into anodes, which are placed in electrolytic tanks and interleaved with thin sheets of pure copper called 'starting sheets'. Application of an electric current causes the anodes to dissolve and form copper cathodes on the starting sheets. Since this electrolytic process is capable of refining the metal to a high degree, the cathode copper usually exceeds 99.97 per cent purity. It is then cast into commercial shapes for industry to process into wire, rod, sheet and strip, tube, or for foundry applications.

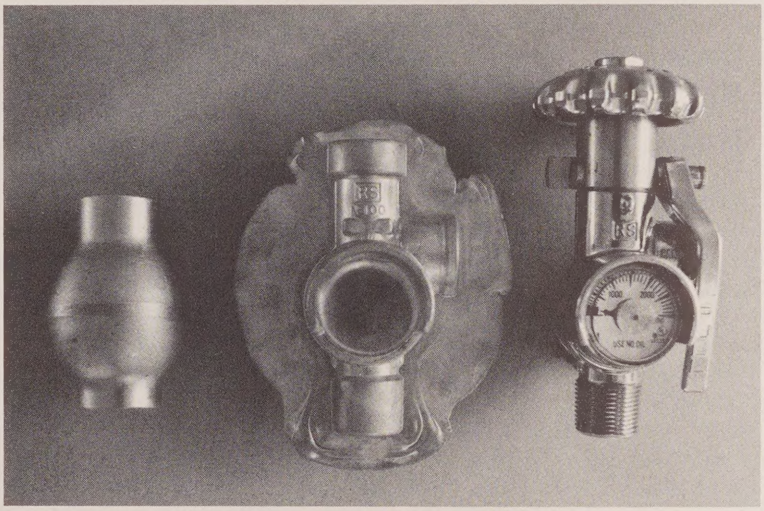
While the sulphur dioxide produced at copper-processing operations poses a hazard to the environment, technologies have been developed to meet stringent new environmental standards. With the development of new processes to capture and treat sulphur dioxide waste gases, copper producers have now also become major producers of sulphuric acid, a valuable industrial product.

Copper smelters in Canada are located in Manitoba, Ontario and Quebec. The Quebec smelters process most of the concentrates produced by small- and medium-sized mines in eastern Canada. As concentrate supplies from eastern Canadian mines have declined in recent years, these plants have supplemented their feedstock requirements with increasing amounts of concentrates imported from offshore as well as with copper-bearing scrap. Most of the copper concentrate produced in British Columbia is exported, principally to Japan. There are three copper refineries: one at Copper Cliff, Ontario; another at Montreal, Quebec; and a third near Timmins, Ontario.

Health and the Environment

Human and animal health depends on an adequate dietary intake of copper (as it does on many other trace metals). Copper combines with proteins to form many enzymes critical for life. One such important enzyme is superoxide dismutase which removes the superoxide radicals in the human body. Superoxide radicals are the "residues" of metabolic processes which otherwise could build up to toxic levels. Copper is also required to transport iron from absorption sites to the bone marrow where red blood cells are produced.

Copper tube used for distribution of potable water supplies has beneficial bactericidal characteristics. It has been noted, for example, that the Legionnella pneumophila bacteria causing Legionnaire's disease and Pontiac fever were present in many hotel sys-



Canadian Copper & Brass Development Association

Forged copper alloys, from pre-formed slug to finished valve.

tems but not in those with copper water systems.

Like most metals, copper is found in small concentrations in nature. The mining of copper generates significant amounts of solid wastes in tailings ponds and, to a lesser extent, in rock dumps. Due to associated minerals such as pyrites in the ore, the wastes generate acid when exposed to oxygen in the air. Commonly, mine operators control acid generation by keeping the tailings areas below the water table and covering acid-generating waste with soil.

Most of the environmental concerns that arise from producing copper are associated with the sulphur dioxide emissions that result from copper smelting. In Canada, Noranda Inc. closed the reverberatory furnace at its Horne smelter in early 1989 and completed construction of a 350 000 tonne per year acid plant at year-end. Noranda thus has the option of re-opening the reverberatory furnace, depending upon feed availability and treatment and refining charges. In Ontario, Inco Limited will spend $69 million to rationalize milling operations and to reduce some sulphur input to the smelting process by selective rejection of iron sulphide. Inco will spend a further $425 million to reduce sulphur emissions from its Sudbury copper and nickel smelters. Falconbridge Limited will spend $38 million to reduce emissions at its smelter in Sudbury.

Finally, Hudson Bay Mining and Smelting Co., Limited plans to modernize its zinc and copper smelters in Manitoba but, while sulphur dioxide emissions will be eliminated in zinc processing in order to meet provincial emission limits, they will not initially be captured at the copper smelter due to the lack of economically viable technology to do so at this time.

Uses of Copper

The early uses of copper were related to its easy workability, softness, resistance to corrosion and its attractive colour and texture. More important properties in its modern uses are its high conductivity of heat and electricity, good tensile strength and mechanical properties, non-magnetic properties and resistance to corrosion. With the development of a broad range of copper-based alloys with enhanced properties, the range of applications for the metal has increased significantly.

The most common alloys may be put into groups: copper and zinc – these are the brasses; copper and tin – these are the 'true' bronzes (all bronzes do not necessarily contain tin); copper and aluminum – the aluminum brasses and bronzes; copper and silicon – the silicon bronzes; and copper and nickel – the cupro nickels, nickel silvers and Monel.

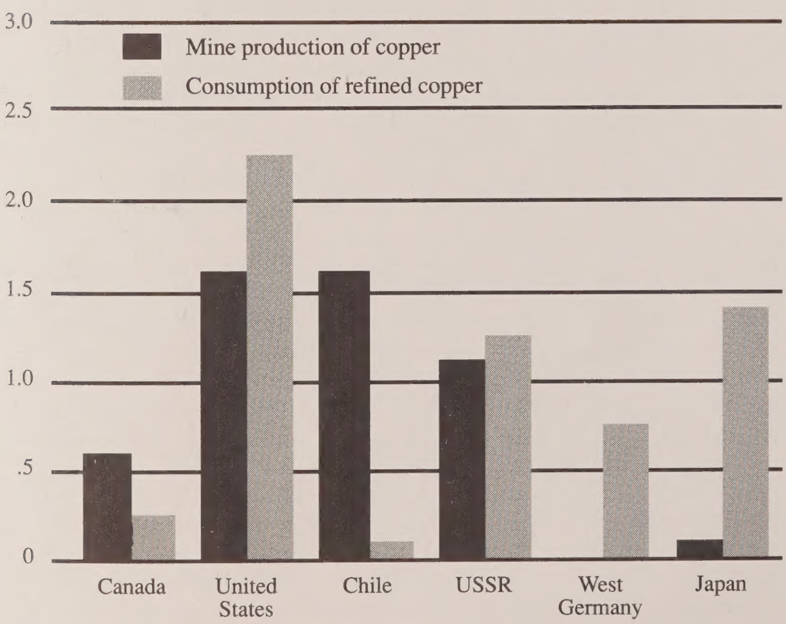
Every element is added for a purpose, usually to improve hardness, resistance to corrosion, machinability, ease of manufacture, or to obtain a desired colour in combination with other properties. There are also special types of copper made by adding small amounts of phosphorus, arsenic, silver, cadmium, lead, silicon, tellurium, chromium and beryllium. Small amounts of copper may be added to steel and cast iron as well as to aluminum to improve their properties.

Some of the most common and widespread applications for copper are in electrical transmissions, water tube, castings and heat exchangers. In Canada, more than half of the approximate 250 000 tonnes of refined copper consumed annually is used for electrical applications, mostly wire. This is manufactured by drawing either continuous cast or hot-rolled copper rod through reduction dies to the desired diameter.

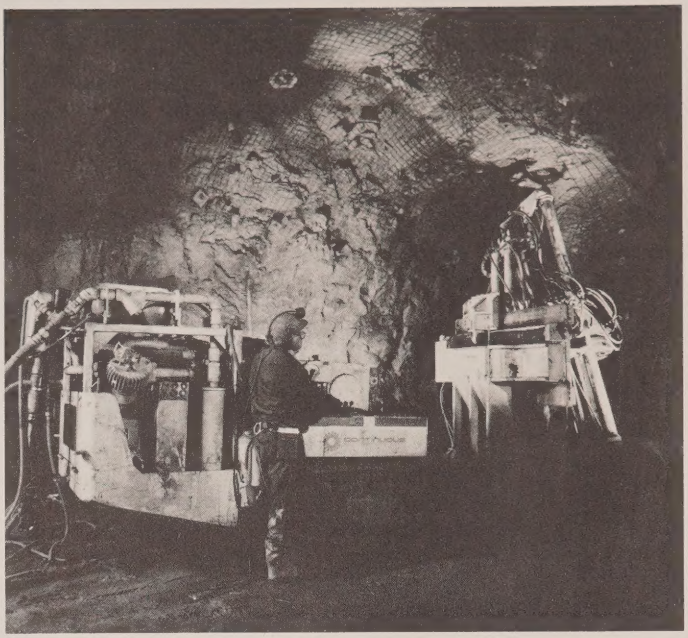
Copper is at the heart of the giant generators at power stations, transformers, electric motors of diesel locomotives, starters and generators of automobiles, and thousands of smaller electric motors, such as those used in household appliances. Copper cables are buried underground to form power and communications networks for cities and towns, and laid beneath the sea to provide links between continents.

With a number of technological

Leading producers and Consumers of copper in 1989 (in millions of tonnes)



advances in the communications and telecommunication sectors in recent years, including the development of fibre optics, multiplexing and gauge reduction, copper utilization in telecommunications has declined. However, copper remains the preferred metal for electrical wiring applications in building construction. It is expected that copper usage in this application will continue to grow as houses increase in size and incorporate more labour-saving electrical devices.



DIVISION LAC DUFAULT, MINNOVA INC.

A down-the-hole electric-pneumatic drill in use at the Ansil Mine in Quebec.

The second greatest consumer of copper is the brass mill industry, which manufactures copper and copper alloy tube and pipe, plate, sheet and strip, and rods, bars and shapes. These products may be used directly, or shipped to other plants for further fabrication. The foundries use large amounts of copper and its alloys for castings of an extensive range of sizes, shapes and types.

In shipbuilding, bronze propellers for all sizes of vessels are made from castings, sometimes weighing as much as 35 tonnes for ocean-going ships. Seawater and freshwater lines on ships are often made of copper or copper alloy tube because of their resistance to corrosion. Desalination plants for making fresh water from seawater, and steam condensers use copper and copper alloy tube for the same reason.

In architecture, the beauty and endurance of the copper metals have made them popular throughout the ages for roofing and decorative features, statuary, bronze doors and windows, distinctive metalwork and hardware of all kinds. Copper roofing is easily recognized by the beautiful pale green patina that forms after a number of years of exposure. This patina is a natural protective coating and is one reason why copper roofing has a very long life.

Inside buildings, copper tube is used for hot and cold water distribution, heating and air-conditioning systems, drainage and fire sprinkler systems. Fuels such as oil and propane gas are often moved through copper tube, and recently there has been a major move to use copper for natural gas systems inside houses and buildings.

The chemical and food-processing industries are major users of copper. Boiling pans in jam making, kettles for brewing beer, distillation equipment for making alcoholic spirits and fractionating columns in the petrochemical industry are typical applications.

Powder forms of copper and its alloys are used in sintering, where solid shapes are made by forming powdered metal under heat and pressure. Powders are also used for coating the backs of mirrors, in paints and inks, such as the 'gold' lettering on packages, and for glazing of pottery.

Copper salts, such as copper sulphate, are used in agriculture as a fungicidal spray or dust, and as an additive for copper-deficient soils. Copper sulphate is also used as an algicide for fishing nets and in reservoirs, swimming pools and farm ponds.

Copper plating is used as a base for nickel or chromium plating on steel parts. It is also applied to other metals as well as to a variety of plastics and nonmetallic materials.

New Markets

A number of promising new markets for copper could well provide significant growth opportunities for the industry by the end of the century. These include applications in roofing, fire suppression systems, natural gas heating systems, as well as solar power generation and data communication. While copper use in original-equipment automobile radiators has declined due to the market penetration of aluminum radiators, copper and brass radiators continue to predominate in the replacement market. In addition, the use of copper in an increased number of automotive electrical circuits is expected to more than offset declining non-electrical copper consumption in vehicles.

Production and Markets

Canadian copper mine production in 1989 was 721 000 tonnes compared to 758 000 tonnes in 1988. Refined production was 511 000 tonnes compared with the record of 529 000 tonnes achieved in 1988. In 1989, the estimated value of copper mine shipments was almost $2.5 billion.

Due to a general decline in base-metal exploration during much of the 1980s, Canadian mine output will actually decline in the early 1990s as existing ore deposits become depleted. While a

number of promising new deposits have been discovered, these will not begin to make a contribution to Canadian output until the second half of the decade.

Canada consumes about 250 000 tonnes of refined copper or about 50 per cent of its total refined production. The remainder is exported, principally to Europe and the United States. With decreasing supplies of metal from central and eastern Canadian mines, production of refined copper has been augmented by the purchase of concentrates, blister and scrap from other countries.

The world's foremost mine producers of copper are Chile, the United States, the U.S.S.R., Canada, Zambia, Zaire, Poland, Peru, Australia, and the Philippine Republic. In addition to these countries, Japan, the Federal Republic of Germany, and Belgium are major producers of refined copper from imported raw material.

Copper mine production in the Western World increased to 7.15 million tonnes in 1989 from 6.70 million tonnes in 1988.

Western World consumption of refined copper increased to 8.40 million tonnes in 1989 from 8.26 million tonnes in 1988. The United States consumes about 25 per cent of the total, followed by Japan (17.5%) and the Federal Republic of Germany (9.5%).

Detailed production and market information on copper can be found in the Canadian Minerals Yearbook.The publication and its price are available from the Canada Communications Group – Publishing, Ottawa, Canada, K1A 0S9, (819) 956-4802.

For more information on Canada's minerals and mining industry, contact:

Mineral Policy Sector
Energy Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 5H3
(613) 995-1118

Aussi disponible en français.

Copper – Technical data

Copper is a metallic element with an atomic number of 29 and an atomic weight of 63.54. The chemical symbol for copper is Cu, from the latin cuprum, and its valencies are 1 and 2.

Copper is referred to as the red metal, since it is the only metal with a natural red colour. It is non-magnetic, and may be used in its pure form or alloyed with other metals to provide a wide range of properties.

Density: 8.9g/cm^3 (at 20°C).

Melting point: 1083°C

Boiling point: 2595°C

Coefficient of linear expansion:

In the temperature range between 20°C and 100°C, it is taken as 16.6 x 10^{-6} per °C.

Copper has the highest electrical conductivity and thermal conductivity of all commercial metals except for silver. The table shows a comparison of these conductivities, with copper indicated as 100.

Tensile strength:

Cast copper has a tensile strength of about 160 MPa (23 000 psi). Working the copper hardens it and increases its strength. Severely cold-worked copper may have a tensile strength of about 450 MPa (65 000 psi). Hardened copper metals may be softened by annealing. This is very advantageous and is done periodically in some manufacturing processes to achieve the final size or shape without rupture of the metal.

Relative Conductivity

Metal	Relative Electrical Conductivity	Relative Thermal Conductivity
Silver	106	106
COPPER	100	100
Gold	72	76
Aluminum	62	56
Magnesium	39	41
Zinc	29	29
Nickel	25	15
Cadmium	23	24
Cobalt	18	17
Iron	17	17
Platinum	16	18
Tin	15	17
Lead	8	9

EMR wishes to thank the Canadian Copper & Brass Development Association for its assistance in the preparation of this brochure.